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TITLE

MARINE FOULING AND CORROSION OF INSTRUMENTATION AT ARGUS ISLAND

AUTHOR

C. F. BECKNER, JR.
OCEANOGRAPHIC PREDICTION DIVISION

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MARINE SCIENCES DEPARTMENT
U. S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

ABSTRACT

This report describes the marine fouling and corrosion of instrumentation at ARGUS ISLAND. Goose barnacles and green and brown algae were the predominant fouling organisms. These organisms generally attached to sensors in areas where antifouling coatings had become chipped or scratched. The severity of fouling indicated seasonal variation.

INTRODUCTION

The Oceanographic Prediction Division of the U.S. Naval Oceanographic Office is engaged in a comprehensive oceanographic research program at the Office of Naval Research Tower, ARGUS ISLAND. ARGUS ISLAND is located at 31°56'55"N, 65°10'45"W, 22 miles southwest of Bermuda, in 192 feet of water and one mile from the edge of Plantagenet Bank. The tower has been utilized for investigations of heat budget, advection, currents, and ocean waves. Current velocity and temperature investigations are also being conducted from an oceanographic instrumented array located approximately 800 feet northwest of the tower.

Attachment and accumulation of marine growth have become significant factors which interfere with accurate data measurements owing to the extended periods of time that sensors are submerged. Marine growth and corrosion appear to affect the calibration of many sensors. This report presents the major observed effects of marine growth upon oceanographic instrumentation at ARGUS ISLAND.

BACKGROUND

"Marine fouling" usually denotes the harmful effects of biological growth or corrosion on submerged man-made structures. Organic and inorganic materials submerged for prolonged periods show evidence of marine growth; however, fouling organisms show a definite preference for, or rejection of, materials of different color or composition. Fouling accelerates corrosion and may damage antifouling materials. The effect of marine fouling on the accuracy of oceanographic instrumentation is of importance to the oceanographer.

Research has shown that sessile fouling organisms apparently increase the corrosion of metals by creation of concentrated oxygen cells at points of adhesion. Metabolic processes of fouling organisms and production of acids and hydrogen sulfide by decaying organisms also appear to abet corrosion and deterioration of various materials.

The severity of fouling depends upon the numbers, growth rate, and size of fouling organisms. These factors are directly related to ecological factors and vary greatly with locality, depth, and season.

OBSERVATIONS

All observations of fouling at ARGUS ISLAND were made visually as sensors were removed from the water. Organisms were identified by comparison with photographs of biological specimens. Goose barnacles, green algae, and brown algae were predominant. In the latter class, large quantities of drifting Sargassum were observed; however, only a few instances of fouling could be attributed directly to this organism. Detailed discussions of fouling on a wave staff, current sensors, and on an instrument array are given below.

Wave Staff:

Barnacles attached to the wave staff appeared to affect its accuracy. The wave staff sensing unit consists of a 50-foot, hollow cylindrical monel tube, 4 inches in diameter. A nichrome wire is stretched through the center of the tube from one end to the other. The tube is slotted every 4 inches to allow sea water access to the wire. In operating attitude, the staff is perpendicular to the sea surface and is half submerged.

The wave staff was installed on ARGUS ISLAND in November 1961. During the first 30 months of wave staff operation, goose barnacles became attached to it at different time intervals but never in large quantities. Fouling increased considerably during the spring of 1964 and became quite severe by June. Many barnacles gained entrance to the tube by way of the sea water access slots, attached to the interior of the tube, and shorted the tube's wall and the nichrome wire, producing spurious wave amplitudes. The intensity of fouling by goose barnacles was greatest approximately 5 to 10 feet below the sea surface; the intensity decreased rapidly with depth.

In October 1964, the wave staff was replaced with an identical sensor. Following a 2-month period of continuous operation, very little fouling by goose barnacles had occurred. The fact that the original wave staff was operative for more than 2 years before barnacle attachment became appreciable may have been due to the seasonal variation of goose barnacles and may have been due partly to depletion of copper in the wave staff over a period of time.

A thin film of algae became attached to the wave staff from time to time but never in sufficient quantity to create a fouling problem. Seasonal variation of fouling due to algae was not determined.

Current Sensors:

Current sensors used at ARGUS ISLAND include the Savonius rotor current meter (figure 1), the Roberts current meter (figure 2), and the Hytech current direction finder (figure 3). The Savonius rotor is constructed of steel and aluminum alloy and has an orange epoxy paint finish. The fittings are bare stainless steel, and the rotors are made of yellow plastic. The Hytech current direction finder consists of a steel case and plastic vanes and is coated with a white antifouling paint. The case, fins, and impeller of the Roberts meter are zinc-plated brass painted with a dark gray epoxy paint. The impeller bearings are diamond chips set in brass.

A Savonius rotor was placed at a depth of 165 feet between 15 June and 7 August 1964. Upon removal of the meter from the water, heavy salt deposits were observed (figure 1a) on the metallic surfaces which were seriously pitted and corroded. A small number of goose barnacles were attached to the meter, and a slight growth of green algae was present on the metallic surfaces. The plastic rotor was relatively free of fouling organisms.

A Savonius rotor was placed at a depth of 45 feet between 30 June and 7 August 1964, and three Roberts meters were placed at depths of 15, 75, and 135 feet. The top and bottom structural plates of the Savonius rotor contained evidence of salt deposits (figure 1b); however, the deposits were not as heavy as those on the rotor placed at 165 feet. The sensor was free of goose barnacles; very little algae were present. The Roberts meters showed no evidence of fouling or corrosion.

On 24 August 1964, a Savonius rotor was installed at a depth of 85 feet. Recovered on 25 September, this rotor showed fairly heavy deposits of salt, serious pitting around the edges of the top and bottom structural plates, and very few goose barnacles (figure 1c). A thin layer of algae covered the metallic surfaces, but the plastic rotor was completely free of fouling.

A Roberts meter was placed at a 25-foot depth from 16 October to 25 November 1964. The meter was relatively free of fouling organisms (figure 2); a few goose barnacles attached to the case of the meter did not affect the accuracy of the instrument. The fins, impeller, and bearings were unfouled. No pitting or corrosion was noted.

Oceanographic Instrument Array:

The array, containing two Hytech current direction finders (figure 3) at depths of 50 and 91 feet and three Savonius rotors (figure 4) at depths of 55, 96, and 137 feet, was installed on 17 August 1964 and remained in operation through 14 October.

Fouling consisted primarily of goose barnacles and green algae, the latter being predominant. Algal growth, which appeared to increase rapidly with depth, was of sufficient severity on the Savonius rotor located at 137 feet to effect a calibration change. A large barnacle was attached to the rotor of the meter at the 55-foot depth. This barnacle was large enough to cause sufficient drag to interfere with accurate data measurements. The Hytech current direction finders were heavily covered with algae and numerous goose barnacles. Algal growth was greater on the plastic vanes than it was on the metallic cases. Barnacles and algae on the vanes of the direction finder located at 91 feet rendered it incapable of responding to changes in current direction after several weeks of operation.

Figure 5 shows a Savonius rotor that was installed on the instrument array at a depth of 95 feet from 4 September to 17 November 1963. A thin layer of algae covered this sensor and the stainless steel float suspended directly above it; few barnacles were evident. Fouling of this sensor was less severe than that of meters installed 17 August to 14 October 1964.

Figure 6 shows an aluminum bracket used for supporting sensors on the instrument array. This bracket, submerged from 17 August to 14 October 1964, was covered with heavy salt deposits. Corrosion of the bracket was severe.

Figure 7 shows the condition of a 3/8-inch galvanized steel shackle attached to the bottom of the tower at a depth of 192 feet from June 1964 to May 1965. The lack of biological fouling on the shackle is sig. ificant.

CONCLUSIONS:

Barnacles appeared to attach to sensors predominantly in areas where antifouling coatings had become chipped or scratched. Fouling due to barnacles was less severe upon array sensors than upon tower sensors, perhaps because the former were newer and their antifouling paint was in better condition.

Fouling due to algae appeared to increase with depth. Algal growth appeared to be more dense on array sensors than upon tower sensors. One possible explanation is that the tower alters normal current flow, resulting in turbulence which impedes the growth of algae.

Marine fouling due to algae and barnacles appeared to be more severe during June, July, and August than in September, October, and November.

FIGURE 1a. SAVONIUS ROTOR PLACED AT 165-FOOT DEPTH, 15 JUNE - 7 AUGUST 1964

FIGURE 1b. SAVONIUS ROTOR PLACED AT 45-FOOT DEPTH, 30 JUNE - 7 AUGUST 1964

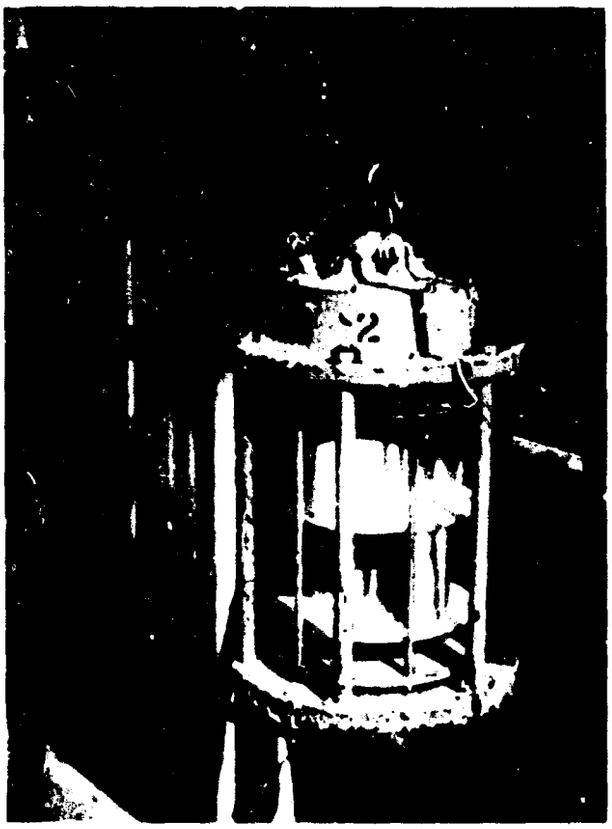

FIGURE 1c. SAVONIUS ROTOR PLACED AT 85-FOOT DEPTH, 24 AUGUST - 25 SEPTEMBER 1964

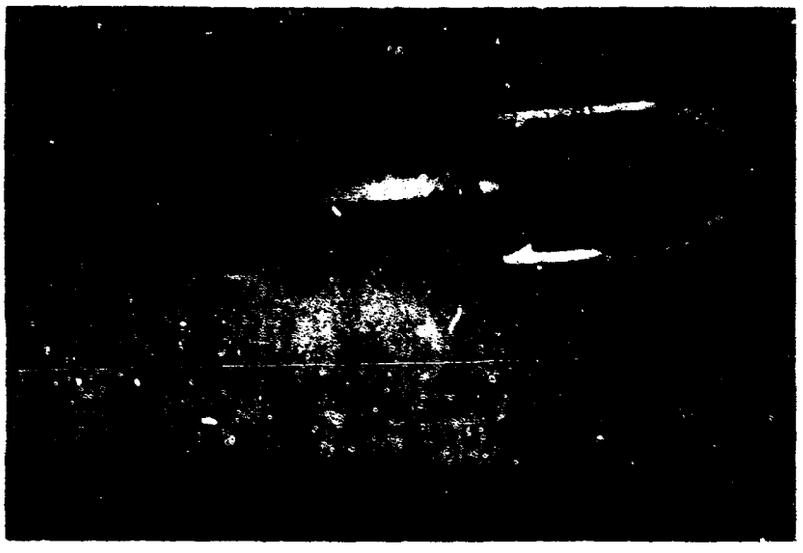

FIGURE 2. ROBERTS CURRENT METER

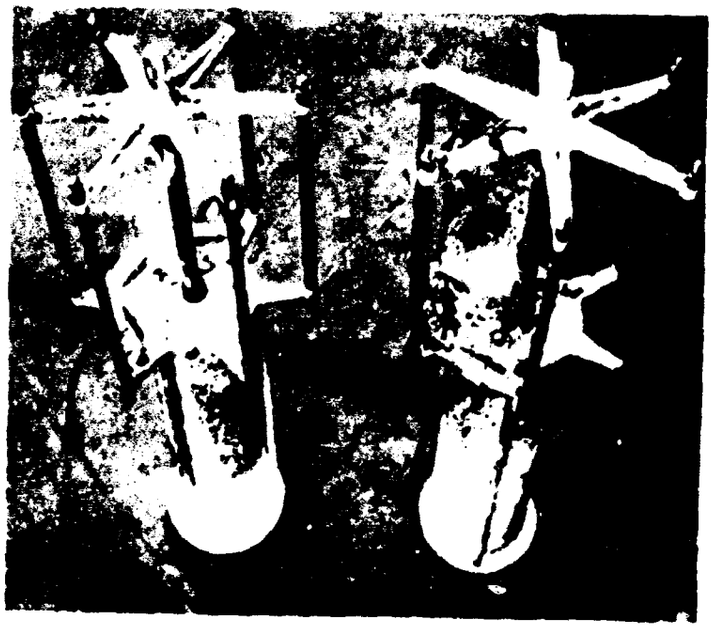

FIGURE 3. HYTECH CURRENT DIRECTION FINDERS PLACED AT 50- AND 91-FOOT DEPTH, 17 AUGUST - 14 OCTOBER 1964

FIGURE 4. SAVONIUS ROTORS PLACED AT DEPTHS OF 137, 96, AND 55 FEET 17 AUGUST - 14 OCTOBER 1964

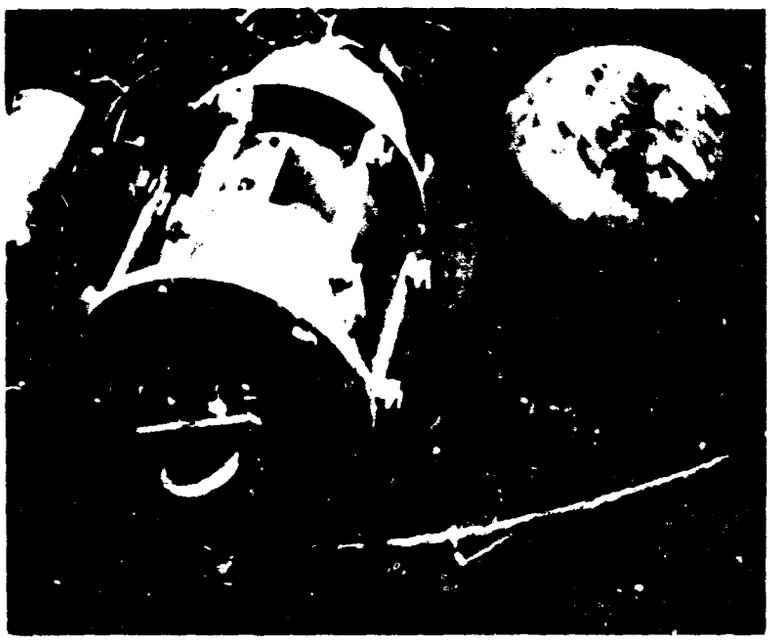

FIGURE 5. SAVONIUS ROTOR AND STEEL FLOAT INSTALLED 4 SEPTEMBER - 17 NOVEMBER 1963

FIGURE 6. ALUMINUM INSTRUMENT BRACKET INSTALLED 17 AUGUST - 14 OCTOBER 1964

FIGURE 7. GALVANIZED STEEL SHACKLE BEFORE AND AFTER SUBMERGENCE FROM JUNE 1964 - MAY 1965